LANE KEEP CONTROL APPARATUS AND METHOD FOR AUTOMOTIVE VEHICLE

BACKGROUND OF THE INVENTION:

Field of the invention

[0001]   The present invention relates to lane keep control apparatus and method for an automotive vehicle to prevent a deviation of the vehicle in which the lane keep control apparatus is mounted (also called, a host vehicle) from a traffic lane on which the vehicle is traveling when the host vehicle is about to be deviated from the traffic lane during the travel of the vehicle.

Description of the related art

[0002]   A Japanese Patent Application First Publication No. Heisei 11-96497 published on April 9, 1999 exemplifies a first previously proposed lane keep control apparatus in which , for example, a controller determines that the host vehicle is about to be deviated from the traffic lane and outputs a steering torque to a degree such that a vehicular driver's force easily overcomes via a steering actuator in accordance with a lateral deviation quantity (variable) of the host vehicle with respect to a reference position of the traffic lane to prevent the host vehicle from being deviated from the traffic lane.

[0003]   In addition, since the above-described first previously proposed lane keep control apparatus requires a steering actuator, for example, a braking force or a driving force is controlled using an anti-skid control system or driving force control system is used to control the braking or driving force.

Consequently, it may be considered that a yaw moment is developed on the vehicle to control a running direction of the host vehicle or running position of the host vehicle. Then, in such a previously proposed

5   lane keep control apparatus as described above, it is desirable that the traffic lane is always continued to be detected. Then, another previously proposed lane keep control apparatus in which, for example, a steering angle is set as a road parameter, a lane

10 marker model such as a white line is set (as disclosed in another Japanese Patent Application No. Heisei 11-296660 published on October 29, 1999).

SUMMARY OF THE INVENTION:

[0004]   However, in order to detect the traffic

15 lane correctly, it is necessary to detect the lane markers at both sides (side ends) of the traffic lane (the traffic lane is usually present on a road segment between two lane markers). Hence, when the lane markers located at both sides of the traffic

20 lane cannot be detected, the above-described second previously proposed lane keep control apparatus suspends the traffic lane keep control. However, when at least one side of the lane markers toward which the host vehicle is deviated can be detected, a

25 condition to continue the lane keep control itself is established. Hence, in this case, if the control is suspended, a deviation from a driver's drive feeling occurs so that the driver tends to give an unpleasant feeling (a sense of incompatibility to the driver

30 occurs).

[0005]   It is, hence, an object of the present invention to provide lane keep control apparatus and method for an automotive vehicle which can eliminate

the deviation in a driver's drive feeling and are capable of not giving the driver a sense of incompatibility thereto.

[0006]   According to one aspect of the present invention, there is provided a lane keep control apparatus for an automotive vehicle, comprising: a traffic lane detecting section that detects a traffic lane on which the vehicle is running; a traveling state detecting section that detects a traveling state of the vehicle; a deviation determining section that determines whether the vehicle has a tendency to be deviated from the traffic lane according to the traffic lane detected by the traffic lane detecting section and the traveling state of the vehicle detected by the traveling state detecting section; and a vehicular behavior controlling section that controls a behavior of the vehicle in such a manner that a yaw moment of the vehicle is developed in a direction to avoid a deviation of the vehicle from the traffic lane in accordance with the traveling state detected by the traveling state detecting section when the deviation determining section determines that the vehicle has a tendency of the deviation of the vehicle from the traffic lane, the traffic lane detecting section including a lane marker detecting section that detects lane markers, each lane marker representing one side of the traffic lane, and the vehicular behavior controlling section controlling the behavior of the vehicle on the basis of the detected lane marker at one side of the traffic lane when the lane marker detecting section transfers a detection state from a state in which both of the lane markers at both sides of the traffic

lane are detected to a state in which the lane marker only at one side of the traffic lane is detected.

[0007] According to another aspect of the present invention, there is provided a lane keep control

5 method for an automotive vehicle, comprising: detecting a traffic lane on which the vehicle is running; detecting a traveling state of the vehicle; determining whether the vehicle has a tendency to be deviated from the traffic lane according to the

10 detected traffic lane and the detected traveling state of the vehicle; and controlling a behavior of the vehicle in such a manner that a yaw moment of the vehicle is developed in a direction to avoid a deviation of the vehicle from the traffic lane in

15 accordance with the detected traveling state when determining that the vehicle has a tendency of the deviation of the vehicle from the traffic lane, during the traffic lane detection, detecting lane markers, each lane marker representing one side of

20 the traffic lane, and controlling the behavior of the vehicle on the basis of the detected lane marker at one side of the traffic lane, when a detection state is transferred from a state in which both of the lane markers at both sides of the traffic lane are

25 detected to a state in which the lane marker only at one side end of the traffic lane is detected.

[0008] This summary of the invention does not necessarily describe all necessary features so that this invention may also be a sub-combination of these

30 described features.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0009] Fig. 1 is a rough configuration view of an automotive vehicle to which a lane keep control

apparatus in a first preferred embodiment according to the present invention is applicable.

[0010]   Fig. 2 is an operational flowchart for explaining a lane keep control procedure executed by a braking/driving force controller in the first preferred embodiment shown in Fig. 1.

[0011]   Fig. 3 is a control map used for calculating a target yaw moment described in the first embodiment and calculated in a lane keep control procedure shown in Fig. 2.

[0012]   Figs. 4A, 4B, and 4C are integrally an explanatory view for explaining an action of the lane keep control procedure executed in the raking/driving force controller described in the first preferred embodiment shown in Fig. 1.

[0013]   Fig. 5 is an explanatory view for explaining an action of the control procedure for a lane marker detection executed in the braking/driving force controller in the first embodiment shown in Fig. 1.

[0014]   Fig. 6 is an explanatory view for explaining an action of the lane keep control procedure executed in the braking/driving force controller described in the first preferred embodiment shown in Fig. 1.

[0015]   Fig. 7 is an operational flowchart executed in the lane keep control apparatus by means of the braking/driving force controller in a second preferred embodiment according to the present invention.

[0016]   Fig. 8 is an operational flowchart executed in the lane keep control apparatus by means of the braking/driving force controller in a third preferred embodiment according to the present invention.

[0017] Fig. 9 is an operational flowchart executed in the lane keep control apparatus by means of the braking/driving force controller in a fourth preferred embodiment according to the present invention.

[0018] Fig. 10 is an operational flowchart executed in the braking/driving force controller in a fifth preferred embodiment according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

[0019] Reference will hereinafter be made to the drawings in order to facilitate a better understanding of the present invention.

[0020] Fig. 1 shows a rough configuration view of an automotive vehicle to which a lane keep control apparatus in a first preferred embodiment according to the present invention is applicable. The vehicle used in the first embodiment is a rear-wheel driven vehicle in which an automatic transmission and a conventional differential gear are mounted and a vehicular brake system is mounted so as to be enabled to control braking forces applied to front left and rear left road wheels independently of each other and front right and rear right road wheels independently of each other. In Fig. 1, in the brake system of the vehicle (host vehicle), a brake pedal 1 is mounted, a brake force (booster) 2 is mounted, a master cylinder 3 is mounted, and a reservoir 4 is mounted. Usually, in accordance with a depression depth of brake pedal 1 by the vehicle driver, a brake fluid pressure boosted by means of a master cylinder 3 is supplied to each wheel cylinder 6FL through 6RR of corresponding one of road wheels 5FL through 5RR (FL

means front left, FR means front right, RL means rear left, and RR means rear right). A brake fluid control circuit 7 is interposed between master cylinder 3 and each wheel cylinder 6FL through 6RR.

5   It is possible to control individually and separately the brake fluid pressure of each wheel cylinder 6FL through 6RR. Brake fluid pressure control circuit 7 utilizes the brake fluid pressure control circuit used in, for example, an anti-skid control system

10   and/or a traction control system. In this embodiment, the brake system is so structured that the brake fluid pressure of each wheel cylinder 6FL, 6FR, 6RL, and 6RR can be increased or decreased individually (solely). Brake fluid pressure control circuit 7

15   controls the brake fluid pressure to each wheel cylinder 6FL through 6RR in accordance with a brake fluid pressure command value from a driving force/braking force controller 8 as will be described later.

20   [0021]   A drive (torque) controller 12 is installed which controls a drive torque to rear left and right road wheels 5RL and 5RR which are driven wheels. A drive state control of an engine 9 can be controlled, for example, by controlling a fuel injection quantity

25   and by controlling an ignition timing. Simultaneously, the drive state control of engine 9 can be controlled by controlling an opening angle of the throttle valve by the drive controller 12. The drive (torque) controller 12 can control drive torque

30   of rear left and right road wheels 5RL and 5RR which are driven wheels, solely, However, when a command value of the drive torque of rear road wheels 5RL and 5RR from braking/driving force controller 8 is

inputted, driven wheel torques are controlled by referring to the drive torque command value.

[0022] In addition, a CCD (Charge Coupled Device) camera 13 and a camera controller 14 are provided as an external world recognition sensor to detect a position of the vehicle itself. Camera controller 14 detects lane markers such as white lines to detect the traffic lane on which the host vehicle is traveling from a photographed image in front of the vehicle trapped by CCD camera 13 and can calculate a yaw angle ϕ of the host vehicle with respect to the traffic lane, viz., a direction of the host vehicle with respect to the traffic lane, a lateral displacement X with respect to the traffic lane, a curvature β of the traffic lane as will be described later, and a traffic lane width L. It is noted that camera controller 14 detects the traffic lane on which the host vehicle is running (traveling) using a traffic lane detection area to detect the lane markers as will be described later. Each of various data is calculated for the traffic lane detected as described above.

[0023] The vehicle shown in Fig. 1 includes: an acceleration sensor 15 to detect a longitudinal acceleration Xg developed on the vehicle and to detect a lateral acceleration Yg; a yaw rate (velocity) sensor 16 to detect a yaw rate ϕ' developed on the vehicle; a master cylinder pressure sensor 17 to detect an output pressure of mater cylinder 3 (so called, a master cylinder pressure Pm); an accelerator opening angle sensor 18 to detect the depression depth of accelerator pedal, viz., opening angle Acc of the accelerator pedal; road

wheel velocity sensors 22FL through 22RR to detect
the revolution speeds of respective road wheels 5FL
through 5RR, so-called, road wheel velocities Vwi (i
= FL, FR, RL, and RR); a steering angle sensor 19 to

5   detect a steering angle δ of steering wheel 21; and a
direction indicator switch 20 to detect a direction
indication operation by means of a direction
indicator. The direction signals are supplied to
driving/braking force controller 8. In addition, yaw

10   angle ϕ of the host vehicle with respect to the
traffic lane detected by camera controller 14, a
lateral displacement X from a center of the traffic
lane therefrom detected by camera controller 14,
lane width L of the traffic lane detected by camera

15   controller 14 are outputted to braking/driving force
controller 8 in addition to drive torque controller
12. It is noted that in a case where a directivity
of the left and right is inherently present in the
running state data of the detected vehicle, a left

20   direction provides a positive direction. That is to
say, yaw rate ϕ', lateral acceleration Yg, steering
angle δ, and yaw angle ϕ are positive values when the
vehicle turns in the leftward direction. Lateral
displacement X is positive value when deviated in the

25   leftward direction from the center of the traffic
lane.
[0024]   Fig. 2 shows an operational flowchart for
explaining a logic of operation executed in
braking/driving force controller in the first

30   embodiment.
[0025]   The calculation processing shown in Fig. 2
is executed for each time of a predetermined sampling
period ΔT, for example, 10 milliseconds as a timer

interrupt routine. It is noted that there is no step
to communicate with any one of the other controllers
and the information obtained by the communication
processing is sequentially stored into a memory and

5   updated and the necessary information is read
arbitrarily from the memory.

[0026]   At a step S110, braking/driving force
controller 8 reads various kinds of data from each
sensor, controller, and other control circuits.

10 Specifically, braking/driving force controller 8
reads longitudinal acceleration Xg, lateral
acceleration Yg, yaw rate ϕ', each wheel velocity Vwi,
acceleration opening angle Acc, master cylinder
pressure Pm, a steering angle sensor δ, direction

15 indicating switching signal, and drive torque Tw from
drive torque controller 12. Then, at step S110,
braking/driving force controller 8 derives a
traveling velocity V of the host vehicle from an
average value of the front road wheel velocities Vw_{FR}

20 and Vw_{FL} which are non-driven wheels. It is noted
that, at this time point, yaw angular displacement
of ϕ, lateral displacement X from the center of the
traffic lane, curvature β of the traffic lane, and
lane width L of the traffic lane are not yet read.

25 [0027]   At the next step S120, using a technique
disclosed in Japanese Patent Application First
Publication No. 11-296660 published on October 29,
1999, a traffic lane detection area, specifically, a
lane marker detection area is set on the basis of a

30 steering angle δ read at step S110 (refer to Figs. 4A
through 4C). On the basis of the set lane marker
detection area, the lane markers located at both
sides of the traffic lane on which the vehicle is

running are detected. Using the detected lane
markers, braking/driving force controller 8 commands
camera controller 8 to detect the running traffic
lane on which the vehicle is running on the basis of
5   the lane marker detection area. At the same time,
braking/driving force controller 8 reads the data of
the yaw angle ϕ of the host vehicle, lateral
displacement X from the center of the traffic lane,
curvature β of the traffic lane, and lane width L of
10   the traffic lane.

[0028]   At the next step S130, braking/driving
force controller 8 determines if the lane markers
located at both sides of the lane on which the
vehicle is running have been detected. If the lane
15   markers located at both sides of the lane are
detected (Yes) at step S130, the routine goes to a
step S140. On the other hand, if have not been
detected (No) at step S130, the routine goes to a
step S150. At step S150, braking/driving force
20   controller 8 determines if only either one of the
lane markers located at one side of the traffic lane
is detected. If only either one of the lane markers
located at one side of the traffic lane is detected
(Yes) at step S150, the routine goes to a step S160.
25   If not either one nor neither all of the traffic lane
is detected (No) at step S150, the routine goes to a
step S170. It is noted that the reason that the
determination of whether either one of the lane
markers locat6ed at either side of the lane is
30   detected or not is that a deviation tendency of the
host vehicle to the traffic lane does not permit the
lane markers located at an opposite side of the
deviation direction to be detected but the lane

marker located at the same side toward which the
deviation of the host vehicle occurs can be deemed to
be enabled to be detected. At step S160,
braking/driving force controller 8 determines if, at
5   a time of a previous calculation cycle (process) of
the present processing of Fig. 2, the lane markers
located at both sides of the traffic lane have been
detected. If Yes at step S160, the routine goes to a
step S140. If No at step S160, the routine goes to a
10   step S180. The reason that the determination of
whether, at the previous calculation shown in Fig. 2,
the lane markers located at both sides of the traffic
lane have been detected is that, in a case where a
state is transferred from a state in which the lane
15   markers located at both sides of the lane markers are
detected to a state in which the lane markers located
at only one side of the traffic lane are detected, it
can be deemed to be a high possibility (a high
certainty) that a certainty that the matters detected
20   at only one side are the lane markers becomes high.
[0029]   At step S170, braking/driving force
controller 8 forces a deviation prevention control
enabling flag (or a lane keep control) enabling flag
F to a reset state of " 0 " .
25   [0030]   Then, the routine goes to step S180. On the
other hand, at step S140, deviation prevention
control enabling flag F is set to " 1 " and the
routine goes to step S180. At step S180,
braking/driving force controller 8 determines if
30   deviation prevention control flag F is set to a state
of " 1 ". If Yes (" 1 ") at step S180, the routine
goes to a step S190. If not (No) at step S180, the
routine goes to a step S210.

[0031]   At step S190, braking/driving force controller 8 calculates a future lateral displacement of Xs as a deviation estimated value and the routine goes to a step S200. Specifically, braking/driving force controller 8 calculates the future lateral displacement in accordance with equation (2) using yaw angle ϕ of the read host vehicle with respect to the traffic lane read at step S120, lateral displacement X from the center of the traffic lane, curvature β of the traffic lane, and a traveling speed V of the vehicle calculated at step S110.   Xs = Tt x V x (ϕ + Tt x V x β) + X --- (2).
In equation (2), Tt denotes a vehicle head-away time used for calculating a distance of a forward observation and Tt multiplied with traveling speed V indicates a forward observation distance.   In other words, the estimated value of lateral displacement X from a center of the traffic lane after the head-away time of Tt denotes a future lateral displacement Xs. As will be described hereinafter, in the first embodiment, braking/driving force controller 8 determines that there is a possibility that the vehicle is deviated from the traffic lane when this future estimated lateral displacement Xs is equal to or larger than a predetermined lateral displacement limit value X_c or determines that the vehicle has the tendency of the deviation.

[0032]   Then, the routine goes to a step S200 from step S190. After, at step S200, braking/driving force controller 8 determines whether the vehicle falls in the deviation tendency from the traffic lane, the routine goes to a step S210. Specifically, when an absolute value |Xs| of the future estimated lateral

displacement as the deviation estimated value calculated at step S190 is equal to or higher than a limit value of the lateral displacement Xc, a deviation determination flag F_{LD} is set since the

5   vehicle has the tendency of deviating from the traffic lane. If not so, deviation determination flag F_{LD} is reset since the host vehicle has no tendency of the deviation from the traffic lane. It is noted that, if the traffic lane change direction

10   estimated by the input from running traffic lane of the vehicle is made coincident with the deviation direction from the traffic lane, deviation determination flag F_{LD} is reset. Then, at step S200, such a determination that some alarming is needed to

15   inform that the host vehicle is tended to be deviated from the traffic lane may be executed. Specifically, the alarming is made by the braking/driving force controller 8 that the absolute value of $|Xs|$ of future estimated lateral displacement as the

20   deviation estimated value calculated at step S190 is equal to or larger than lateral displacement limit value X_c which is a subtraction of a half value of vehicle width L_0 of the host vehicle from a half value of width L of traffic lane read at step S120.

25   If not so, no alarming is made. There may be any other informing method.

[0033]   At a step S210, braking/driving force controller 8 calculates and sets target yaw moment Ms to prevent the traffic lane from being deviated

30   therefrom. It is noted that, since target yaw moment Ms is set only when deviation determination flag F_{LD} is set, target yaw moment Ms is calculated in accordance with the following equation (3). It is

also noted that, when deviation determination flag
F_{LD} is reset, target yaw moment Ms is forced to zero
(" 0 "). Next, the routine goes to a step S220. At
step S220, braking/driving force controller 8

5 calculates target braking/driving fluid pressure Psi
and a target driving force for the driven wheels
(rear left and right road wheels (5RL and 5RR).
Specifically, suppose that rear road wheel master
cylinder pressure based on the longitudinal (forward-

10 and-rearward) braking force distribution is P_{mR} with
respect to master cylinder pressure Pm read out at
step S110 when deviation determination flag F_{LD} is
reset. Target braking fluid pressure P_{sFL} and P_{sFR} for
front left and right road wheels 5FL and 5FR using

15 wheel cylinders 6FL and 6FR indicate master cylinder
pressure Pm. Target braking fluid pressures P_{sRL} and
P_{sRR} toward wheel cylinders 6RL and 6RR of rear left
and right road wheels 5RL and 5RR are, respectively,
rear road wheel master cylinder pressure P_{mR}. On the

20 other hand, even if deviation determination flag F_{LD}
is set, a situation branching is carried out in
accordance with a magnitude of target yaw moment Ms
calculated at step S210. That is to say, if an
absolute value |Ms| of target yaw moment is smaller

25 than a predetermined value M_{s0}, a difference is
developed only by the driving force for rear left and
right road wheels 5RL and 5RR. Hence, if front left
and right road wheel braking fluid pressure
difference ΔP_{sF} when an absolute value |Ms| of target

30 yaw moment is less than predetermined value M_{s0} is
zero and rear left and right road wheel target
braking fluid pressure difference ΔP_{sR} is given in
the following equation (4). In the similar manner,

front left and right road wheel target braking fluid pressure difference ΔP_{sF} when absolute value $|Ms|$ of target yaw moment is equal to or larger than a predetermined value M_{s0} is given in the following

5   equation (5). Rear left and right road wheel target braking fluid pressure difference ΔP_{sR} is given in the following equation of (6). In equations (4) through (6), T denotes a tread (assuming that the tread is the same between the front and rear road

10   wheels) and K_{bF} and K_{bR} denote conversion coefficients to convert the driving force into the braking fluid pressure and is determined according to braking specifications.

$$\Delta P_{sR} = 2 \times K_{bR} \times |Ms|/T \quad \text{---} \quad (4)$$

15
$$\Delta P_{sF} = 2 \times K_{bF} \times (|Ms| - M_{s0})/T \quad \text{---} \quad (5)$$

$$\Delta P_{sR} = 2 \times K_{bR} \times |M_{s0}|/T \quad \text{---} \quad (6)$$

Hence, if target yaw moment Ms is a negative value, namely, target braking fluid pressure Psi to each wheel cylinder 6FL through 6RR when the vehicle

20   traveling direction is about to be deviated toward a leftward direction, target braking fluid pressure Psi is given in the following equation (7) (i = FL, FR, RL, RR).

$$P_{SFL} = Pm$$

25
$$P_{SFR} = Pm + \Delta P_{SF}$$

$$P_{SRL} = Pm$$

$$P_{SRR} = Pm + \Delta P_{sR} \quad \text{---} \quad (7).$$

[0034]   On the other hand, if target yaw moment Ms is a positive value, target braking fluid pressure

30   Psi for each wheel cylinder 6FL through 6RR when the host vehicle is about to be deviated toward a

rightward direction, target braking fluid pressure
Psi is given in the following right equation.

$$P_{sFL} = Pm + \Delta P_{SF}$$

$$P_{sFR} = Pm$$

5    $$P_{sRL} = Pm + \Delta P_{sR}$$

$$P_{sRR} = Pm \qquad --- (8).$$

[0035]   In addition, in this embodiment, when
deviation determination flag F_{LD} is set to " 1 " and
the traffic lane keep control is executed, the engine

10   output is throttled so that a vehicular acceleration
cannot be carried out even if a manipulation of
accelerator pedal is carried out. Hence, target
drive torque Trq_{DS} when deviation determination flag
F_{LD} is set is charged from the value in accordance

15   with accelerator opening angle Acc read at step S110
from which a sum of front and rear road wheel target
braking fluid pressure difference ΔP_{SF} and ΔP_{SR} is
subtracted. In other words, the vehicle in
accordance with accelerator opening angle value

20   indicates the drive torque to accelerate the vehicle
in accordance with the accelerator opening angle Acc.
The value in accordance with the sum of the front and
rear target braking fluid pressure difference ΔP_{SF}
and ΔP_{SR} indicates the drive torque developed

25   according to a sum of the target brake fluid pressure
difference ΔP_{SF} and ΔP_{SR}.
[0036]   Hence, when the lane keep control (traffic
lane deviation prevention control) is executed, with
deviation determination flag F_{LD} set. The engine

30   torque is reduced by the drive torque developed by
the sum of ΔP_{sF} and ΔP_{sR}. It is noted that target
drive torque trq_{DS} when deviation determination flag

F_{LD} is reset is only the drive torque to accelerate the host vehicle in accordance with accelerator opening angle Acc. At the next step S230, braking/driving force controller 8 outputs the target
5 braking fluid pressure toward braking fluid pressure control circuit 7, outputs the target drive torque to drive torque controller 12, and the routine of Fig. 2 is returned at a main program (not shown).

[0037]   Next, the action of tracing the lane
10 markers will be described below. In this embodiment, for example, as shown in Figs. 4A, 4B, and 4C, from among images photographed with CCD camera 13, the lane marker detection area is set to detect the lane markers such as white lines. Specifically, when the
15 lane markers are detected (scanned) over the whole area of the image photographed, a calculation load is heavy and it takes a lot of time for an image processing. Therefore, a further smaller detection area (so-called, a window and this is the lane marker
20 detection area) is set on regions of an image screen having a high possibility of a presence of the lane markers and the lane marker is detected within the detection regions. In general, since, if this direction of the host vehicle with respect to the
25 traffic lane is changed, the positions of the lane markers on the image screen are also changed. Hence, in the above-described Japanese Patent Application First Publication No. Heisei 11-296660 published on October 29, 1999, the direction of the vehicle with
30 respect to traffic lane is estimated from steering angle δ, the detection regions are set on areas, each area having a high possibility of being viewed in the image screen. Then, when a further processing such

as to become conspicuous (high contrast) with a
boundary between the lane marker and road surface is
carried out, a straight line which can be deemed to
be a most probable boundary line between the lane
5   marker and road surface is detected. A single point
on the straight line (lane marker candidate point) is
detected as a representative position of the lane
marker. In this embodiment, as shown in Fig. 5, an
uppermost point as a result of the detection is
10   detected as a lane marker candidate point. The
number of lane marker candidate points become equal
to or greater than a preset value (PREF). At this
time, the detected lane markers are deemed to be
correct. On the other hand, if the number of lane
15   marker candidate points are less than the preset
value, the detected lane markers are not deemed to be
correct. Furthermore, if a total number of the lane
marker candidate points for those located at both
sides of the traffic lane is not equal to nor larger
20   than the preset value, the lane markers located at
both sides of the lane markers are not correctly
detected. According to the calculation processing of
Fig. 2, the deviation prevention control (lane keep
control) enable flag F is set when the lane markers
25   located at both sides of the traffic lane are
detected. Then, when no intentional traffic lane
change by the drive occurs and future estimated
lateral displacement Xs becomes equal to or larger
than lateral displacement limit value X_c, the host
30   vehicle is determined that the vehicle tends to be
deviated from the traffic lane, deviation
determination flag F_{LD} is set, target yaw moment Ms
on the basis of the difference between the future

lateral displacement Xs and lateral displacement limit value X_c, and the braking force of each road wheel is controlled so as to achieve the target yaw moment. Thus, when, for example, steering input is

5 small, the yaw moment is developed to prevent the vehicle from being deviated from the traffic lane and the vehicular velocity is reduced due to the braking force. Hence, a more safe deviation of the vehicle from the traffic lane can be prevented. In the first

10 embodiment, while the lane keep control is executed, the output torque of the engine is reduced and traveling speed V of the vehicle is reduced. Hence, a further safety vehicular deviation from the traffic lane can be prevented.

15 [0038]   In addition, in this embodiment, even when the lane marker located only at one side of the traffic lane can be detected, deviation prevention control enable flag F is set when the lane markers at both sides of the lane were previously detected.

20 Thus, in the same way as the detection of the lane markers at both sides of the traffic lane, the lane keep control to prevent the host vehicle from being deviated from the traffic lane is continued to be carried out. Consequently, even if only the lane

25 marker at one side, for example, present in the deviation direction is detected, the lane keep control is continued. It gives the vehicle driver no sense of incompatibility without deviation from the drive feeling.

30 [0039]   Each sensor shown in Fig. 1, camera controller 14, and steps S110 and S120 constitute traveling state detecting means (section) and step S120 shown in Fig. 2 constitutes traffic lane

detecting means (section) and lane marker detecting
means (section). Steps S190 and S200 in Fig. 2
constitute deviation determining means (section).
Steps S210 and S230 constitute vehicular behavior
5   controlling means (section), braking fluid pressure
control circuit 7 and drive torque controller 12
shown in Fig. 1 constitute vehicular behavior
controlling means (section), and step S230 in Fig. 2,
the braking fluid pressure control circuit 7 and
10 drive torque controller 12 constitute braking-and-
driving force controlling means (section).
[0040]   Next, a second preferred embodiment of the
vehicular lane keep control apparatus according to
the present invention will be described. The
15 hardware structure in the second embodiment is
generally the same as that of the first embodiment
shown in Fig. 1. Fig. 7 shows an operational
flowchart of the lane keep control executed in the
second embodiment of the lane keep control apparatus
20 of braking/driving force controller 8. The same
numbered steps shown in Fig. 7 correspond to the like
steps of the same numbered steps shown in Fig. 2.
Hence, the same step numbers as shown in Figs. 2 and
7 will be omitted herein. A step S131 is interposed
25 between steps S130 and S140, a step S161 is
interposed between steps S150 and S140, and a step
S162 is interposed between steps S150 and S170.
[0041]   That is to say, at step S131 shown in Fig.
7, both-side lane marker detection counter CNT as
30 will be described later is incremented and the
routine shown in Fig. 7 goes to step S140. At step
S161, braking/driving force controller 8 determines
if both-side lane marker detection counter CNT is

equal to or greater than a predetermined value CNTo.
If CNT ≥ CNTo at step S161 (Yes), the routine goes to
step S140. If No (CNT < CNTo) at step S161, the
routine goes to step S162. At step S162, both-side

5 lane marker detection counter CNT are cleared and the
routine goes to step S170. According to the
calculation processing described above, both-side
lane marker detection counter CNT is incremented when
the lane markers located at both sides of the lane

10 are detected and, when the lane marker located at
only one side can be detected (at step S150),
deviation prevention control enable flag F is set
provided that the count value of both side lane
marker detection counter CNT is equal to or greater

15 than predetermined value CNTo, the lane keep control
(traffic lane deviation prevention control) is
carried out in the same way as the first preferred
embodiment. It is noted that both-side lane marker
detection counter CNT represents the certainty of the

20 detection of the lane markers located at both sides
of the traffic lane. If this certainty is high, the
lane keep control is continued even if only the lane
marker located at one side of the lane is detected.
Usually, even if the lane marker is detected only at

25 one side of the lane, the traffic lane keep control
is continued. Usually, when the vehicle is tried to
be deviated from the traffic lane on which the
vehicle is running, as appreciated from Figs. 4A, 4B,
4C, and 6, at first, the lane markers located at both

30 sides of the lane are detected and, soon, only the
lane marker located at one side which is in the
deviation direction is detected. Hence, if the
detection time duration of the lane markers located

at both sides of the lane is long and, thereafter,
only the lane marker at either side of the traffic
lane cannot be detected, the vehicle tends to be
about to be deviated. Hence, if the lane keep

5 control is continued, a suppression of the vehicle
from the deviation thereof from the traffic lane can
be assured.

[0042]   As described above, in the second
embodiment, each sensor shown in Fig. 1, camera

10 controller 14 and steps S110 and S120 shown in Fig. 7
constitute traveling state detecting means (section),
step S120 shown in Fig. 7 constitutes traffic lane
and lane marker detecting means (section), step S131
in Fig. 7 and step S161 constitute lane marker

15 certainty detecting means (saection), step S190 and
step S200 shown in Fig. 7 constitutes deviation
determining means (section), steps S210 through S230,
the brake fluid pressure control circuit 7 and drive
(torque) controller 12 constitutes vehicular behavior

20 controlling means (section). Step S130 shown in Fig.
7, brake fluid pressure control circuit 7 shown in
Fig. 1, and drive (torque) controller 12 constitute
braking/driving force controlling means (section).

[0043]   Next, a third preferred embodiment of the

25 traffic lane keep control apparatus according to the
present invention will be described below.

[0044]   The rough configuration of the vehicle is
the same as that described in the first embodiment
with reference to Fig. 1.

30 [0045]   In the third embodiment, the flowchart
shown in Fig. 8 is executed in place of Fig. 2
described in the first embodiment. However, since
the same numbered steps described in the steps shown

in Fig. 8 as those shown in Fig. 2 are present, the
different steps will only be described below. That
is to say, step S160 shown in Fig. 2 is changed to a
step S163. At step S163, braking/driving controller

5 8 determines whether the number of lane marker
candidate points of the lane marker located at one
side which cannot be detected (in Fig. 8, called lost
side) is equal to or greater than a predetermined
value (PREF). If the lost side lane marker candidate

10 points is equal to or greater than predetermined
value (PREF), the routine goes to step S140. If the
number of lane marker candidate points is less than
predetermined value Ref (No) at step S163, the
routine goes to step S170. It is noted that

15 predetermined value PREF of the number of lane
markers candidate points is different from
predetermined value to determine that the lane
markers are correctly detected and indicate smaller
value. In the calculation processing, in addition to

20 an action of the first preferred embodiment, when
only the lane number located at only one side of the
traffic lane cannot be detected, lane keep control
enable flag F is set to " 1 " at step S140 provided
that the number of lane marker candidate points

25 located at the opposite side which cannot be detected
is equal to or greater than predetermined values PREF
and the lane keep control is carried out in the same
way as the first embodiment. It is noted that if the
lane marker is a white dot line, even if the lane

30 marker is correctly detected, there is a possibility
that the lane marker candidate point is less than the
predetermined value of a boundary of whether the lane
marker is correctly detected. Then, even if only one

side lane marker can correctly be detected, the
number of lane marker candidate points is equal to or
greater than predetermined value, the lane keep
control is continued so that the lane keep control
5 permits the assured vehicular deviation prevention
from the deviation from the traffic lane.
[0046]   As described above, each sensor shown in
Fig. 1, camera controller 14, and steps S110 and S120
shown in Fig. 8 constitute traveling state detection
10 means (section) in the case of the present invention,
step S120 shown in Fig. 8 constitutes the traffic
lane detection means (section) and lane marker
detecting means (section), step S163 shown in Fig. 8
constitutes lane marker certainty detecting means
15 (section), steps S190 and S200 shown in Fig. 8
constitutes deviation determining means (section),
steps S210 through S230 shown in Fig. 8, braking
fluid pressure control circuit 7 shown in Fig. 1, and
drive (torque) controller 12 constitute vehicular
20 behavior controlling means (section), and step S230
shown in Fig. 8, braking fluid pressure control
circuit 7, and drive (torque) controller 12
constitute braking/driving force controlling means
(section).
25 [0047]   Next, a fourth preferred embodiment of the
lane keep control apparatus according to the present
invention will be described below.   The structure of
the vehicle to which the lane keep control apparatus
is applicable is the same as described in the first
30 embodiment shown in Fig. 1.
[0048]   In the fourth embodiment, the flowchart
described in the first embodiment with reference to
Fig. 2 is modified to that shown in Fig. 9. Although

the same numbered steps as those shown in Fig. 2 are
present in the flowchart of Fig. 9, the details
description thereof will herein be omitted. The
different points are a step S132 which are interposed
5   between steps S130 and S140, a step S164 which are
interposed between step S160 and S140, and step S210
is wholly changed to a step S211.

[0049]   That is to say, at step S132, a target yaw
moment proportional coefficient k is set to " 1 " and
10 the routine goes to step S140. At step S164, target
yaw moment proportional coefficient k is set to a
predetermined value smaller than " 1 " and the
routine goes to step S140. Then, at step S211,
target yaw moment Ms calculated at equation (3) is
15 multiplied with target yaw moment proportional
coefficient k to set the value to a new target yaw
moment Ms and the routine goes to step S220.

[0050]   According to the calculation processing,
in addition to the action in the first embodiment,
20 when a state in which the lane markers located at
both sides of the traffic lane have been detected to
a state in which only the lane marker located at only
one side is detected, a target yaw moment
proportional coefficient k which is constituted by a
25 predetermined value k_0 smaller than one is set.
Target yaw moment Ms is a controlled output of the
lane keep control apparatus according to the present
invention, a gain is modified to be smaller so that
the controlled output when only one-side lane marker
30 can be detected is adjusted to be smaller than that
when both sides lane markers are detected. As
described above, when the state is transferred from
the state in which the lane markers located at both

sides of the traffic lane are detected to a state in which the lane marker located only at either side of the traffic lane becomes detected, there is a high possibility that the vehicle is tended to be deviated

5 in the deviation direction. Hence, it is desirable to continue the lane keep control. However, it can be said that the traffic lane is not accurately detected. Hence, during the detection of one-side lane marker, while the controlled output is reduced as described

10 in the fourth embodiment, the lane keep control is continued so that an appropriate lane keep control under such a situation as described above can be achieved. It is noted that gain constituted by target yaw moment proportional coefficient k is

15 varied in a stepwise manner but may be varied in a continuous manner. A method of reducing the controlled output can be carried out by reducing the number of times the control processes are executed or by shortening the continuous time duration of the

20 control.

[0051] Each sensor shown in Fig. 1, camera controller 14, and steps S110 and S120 shown in Fig. 9 constitute traveling state detecting means (section) according to the present invention, step

25 S120 shown in Fig. 9 constitutes traffic lane detecting means (section) and lane marker detecting means (section), step S190 shown in Fig. 9 and step S200 constitute deviation determining means (section), steps S211 through S230, braking fluid pressure

30 control circuit 7, and drive (torque) controller 12 constitutes braking/driving controlled variable calculating means (section), and step S230 in Fig. 9, braking fluid pressure control circuit 7 shown in Fig.

1, and the drive torque control circuit 12 constitute
braking/driving force controlling means (section).

[0052]   Next, a fifth preferred embodiment of the
lane keep control apparatus according to the present
invention will be described below. The rough
configuration of the vehicle to which the lane keep
control apparatus in the fifth embodiment is
applicable is the same described in the first
embodiment as shown in Fig. 1. The operational
flowchart executed by braking/driving force
controller 8 is changed from that shown in Fig. 2 to
Fig. 10 in the fifth preferred embodiment. The same
numbered steps shown in Fig. 10 are the same as shown
in Fig. 2 so that the detailed description thereof
will herein be omitted. The difference points are a
step S133 interposed between steps S130 and S140 and
a step S165 interposed between steps S160 and S140.

[0053]   At step S133 in Fig. 10, braking/driving
force controller 8 changes from lateral displacement
limit value X_c to determine the deviation tendency
directly to the lateral displacement limit value X_c
and goes to step S140. At step S165, braking/driving
force controller 8 sets the lateral displacement
limit value of X_c to determine the deviation tendency
to a predetermined value of X_{c0} which is greater than
lateral displacement limit value X_c. In Fig. 10, in
addition to the action in the case of the first
embodiment, when a state from a state in which the
lane markers located at both sides of the traffic
lane have been detected to a state in which only the
lane marker located at either side of the traffic
lane is detected, predetermined value X_{c0} which is
larger than the natural (original) lateral

displacement limit value (control threshold value) X_c
is set to the new lateral displacement limit value X_c
and the determination of the deviation tendency is
carried out using this lateral displacement limit

5   value X_c. In this case, since, if an absolute value
$|Xs|$ of the future estimated lateral displacement is
equal to or greater than lateral displacement limit
value X_c, deviation determination flag F_{LD} is set due
to the deviation tendency from the traffic lane of

10 the vehicle, it is difficult to determine the
deviation tendency if lateral displacement limit
value X_c becomes large and a timing at which the lane
keep control is interrupted becomes late. That is to
say, target yaw moment Ms indicates zero. In addition,

15 target yaw moment Ms calculated in equation (3)
indicates a smaller value and the controlled output
of the lane keep control apparatus in the fifth
embodiment is adjusted to be a smaller value. That
is to say, target yaw moment Ms is the controlled

20 output of the lane keep control apparatus in the
fifth embodiment. That is to say, target yaw moment
Ms is the controlled output of the lane keep control
apparatus in the fifth embodiment. Since the
control threshold value X_c is largely modified, the

25 controlled output when only the lane marker located
at one side of the traffic lane can be carried out is
adjusted to be smaller than the controlled output at
which the lane marker at both sides thereof is
detected. As described above since when the state

30 is transferred from the lane markers located at both
sides of the traffic lane are detected to the state
in which the lane marker located only at one side of
the traffic lane becomes detected, there is a high

possibility that the deviation from the lane tends to occur in the direction toward which only the lane marker locate only at one side is detected. Hence, it is desirable to continue the traffic lane

5   deviation prevention control (lane keep control). However, the traffic lane on which the vehicle is running cannot still be perfectly accurately be detected. When the lane marker located only at one side is detected, the lane keep control is continued

10   while reducing the controlled output as in the fifth embodiment, the appropriate traffic lane keep control can be achieved under such a situation as described above. In the fifth embodiment, a threshold value of lateral displacement limit value X_c is varied in the

15   stepwise manner, it may be varied continuously.
     [0054]   As described above, each sensor shown in Fig. 1, camera controller 14, and steps S110 and S120 shown in Fig. 10 constitute traveling state detecting means (section), step S120 shown in Fig. 10

20   constitutes traffic lane detecting means (section) and lane marker detection means (section), steps S190 and S200 constitute deviation determining means (section), steps S190 and S210 shown in Fig. 10 constitute deviation determining means (section),

25   step S133 shown in Fig. 10, step S165, and steps S210 through S230, braking fluid pressure control circuit 7, and drive (torque) controller 12 constitute vehicular behavior (motion) controlling means (section), step S220 shown in Fig. 10 constitute

30   braking/driving force controlled variable calculating means (section). Step S220 in Fig. 10 constitutes braking/driving force controlled variable calculating means (section) and step S230 in Fig. 10, braking

fluid pressure control circuit 7 shown in Fig. 1, and drive (torque) controller 12 constitute braking/driving force controlling means (section).

[0055]   It is noted that, in each of the first through fifth embodiments, lateral displacement limit value X_c which is the control threshold value of determining the deviation of the vehicle from the traffic lane is calculated according to the vehicular width and traffic lane width. However, for example, since the traffic lane width in the case of a Japanese domestic high-speed express way is fixed as 3.35 meters, lateral displacement limit value X_c may be fixed to, for example, 0. 8 meters. It is noted that the driving force defined in the claims includes the braking force since the braking force is negative to the driving force.

[0056]   The entire contents of a Japanese Patent Application No. 2002-342054 (filed in Japan on November 26, 2002) are herein incorporated by reference. The scope of the invention is defined with reference to the following claims.